NASA
National Aeronautics and
Space Administration

Information Summaries

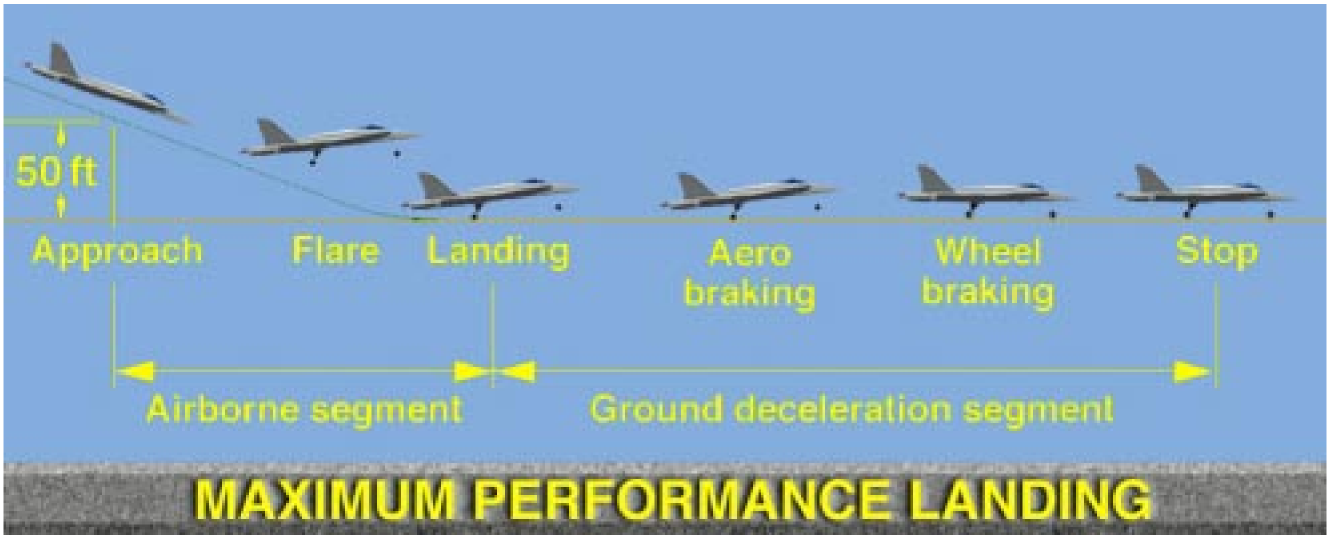
IS-97/08-DFRC-L1

Maximum Performance Landing

Background

The landing is a critical maneuver in any airplane. The airplane will usually be carrying a payload (passengers, cargo, weapons) but will usually be at light weight having expended most of its fuel. Landings may be required at any time, however, so the maximum performance landing must be tested over a wide range of weights. The maximum performance landing is the inverse of the maximum performance takeoff. The airplane will fly over a 50 foot obstacle, then land and stop in the shortest possible distance.

The Maximum Performance Landing test will determine the best landing technique and the length of runway required to bring the airplane to a stop after passing over a 50 foot obstacle. It is strongly influenced by weight and piloting technique, and to a lesser extent by field elevation. The landing maneuver is divided into two segments; the airborne segment (a slow and steep approach followed by a flare and landing), and the ground segment (a rapid deceleration using both aerodynamic braking and wheel braking).



Different techniques will be tried during portions of some landings to determine the optimum technique for each segment. For example, various speeds for performing the transition between aerodynamic braking (speed brakes or thrust reversing, full flaps, or nose held up by pitch control) to wheel braking (flaps up, nose down and maximum wheel brake) will be tried. Various approach speeds and flap settings will also be tried to provide the steepest and slowest possible approach speed at 50 feet altitude, while maintaining enough energy to flare and land smoothly. These tests will determine the best approach speed and flap configuration for various weights.

Once the best piloting techniques for the individual segments of the landing are defined, the complete maximum performance landing tests will be performed.

1.Specific Objective of the Test

The primary purpose of the max performance landing test is to establish a piloting technique that will minimize the distance required to land and slow to a stop after passing over a 50-foot-high obstacle, then measure that distance for a particular weight. The results of these tests will help the users of the airplane to establish the minimum runway length that the airplane can be operated from safely.

2. Critical Flight Conditions

The most critical conditions for a max performance landing test are:

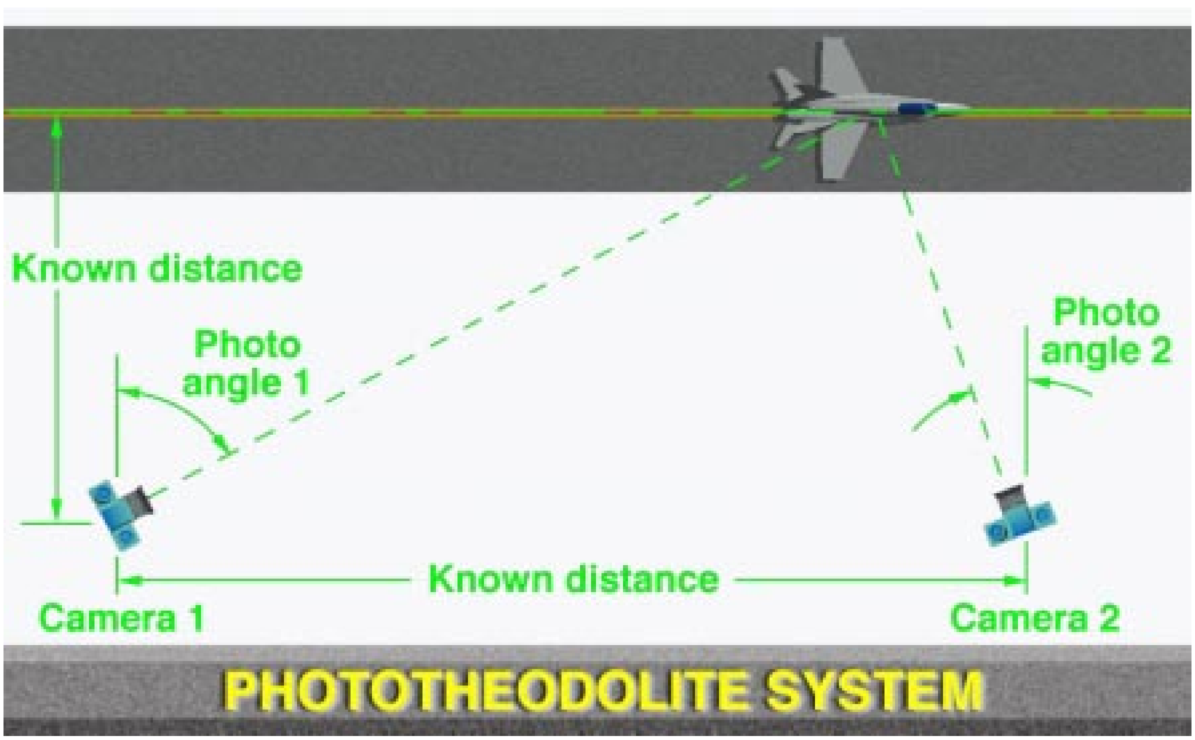
- Weight (Several values will be tested - must be accurately known.)
- Field Elevation - (Affects true speed at touchdown)
- Energy capacity of the brakes - (potential for brake fires and blown tires)
- Surface winds - (as close as possible to zero wind)

3. Required Instrumentation

The parameters usually measured and recorded during a maximum performance landing are shown in Table (1-1). The engine instruments shown are representative but not complete. The engine instrumentation will be used to correct the thrust and fuel flow data to standard day pressures and temperatures.

The normal pressure altitude measurements do not provide sufficient accuracy to locate the point during the landing that the airplane had passed through exactly 50 feet in altitude. Several measurement techniques have been developed for determining both the distance along the runway and the altitude above the runway.

Phototheodolite measurements are photos taken of the airplane during the landing using several cameras in fixed locations. The cameras are linked together and have been carefully calibrated so that the image of the airplane in the photos can be used in a triangulation process to accurately determine both the location of the airplane during its final approach to the runway and during its deceleration on the runway.



In recent years the phototheodolite method has been augmented or replaced by on-board inertial measurements and a radar altimeter to determine location and altitude above the runway.

A continuous time history of these parameters is needed throughout the actual maneuver which usually begins at some point on final approach. A sampling rate of at least 10 data samples every second is necessary to accurately record the maneuver, and each data sample must be accurately time correlated with the data samples of the other parameters. If photothoedolite methods are used, an accurate time correlation must be established between the on-board instrumentation measurements and the external phototheodolite measurements. That is, we must be able to relate a particular measurement of airspeed and time with a measurement of runway location and altitude above the runway.

There are several key events during the landing that must be accurately identified both in time and distance from the airplane's stopping point. They are:

- Altitude of 50 feet - (photos or radar altimeter)
- Main wheel touchdown - (photos or shock strut extension)
- Nosewheel touchdown - (photos or shock strut extension)
- Wheel stop - (photos or inertial system)

Once the time for each of these events is accurately identified, the engine data, airspeeds, etc. can be accurately calculated.

4. Starting Trim Point

The starting point for a max performance landing is a stabilized final approach condition using the optimized techniques developed for the current aircraft weight. Landings at different weights (or at different field elevations) will be accomplished using different approach speeds as dictated by the conditions.

5. Description of a Maximum Performance Landing

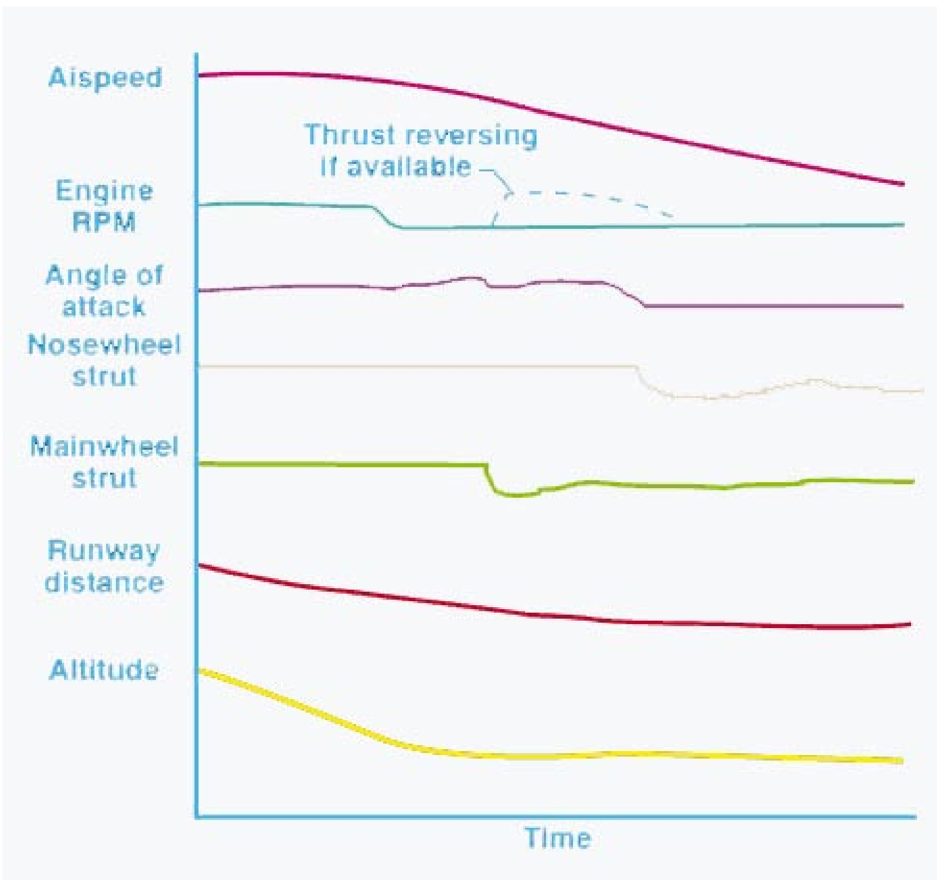
The test begins with a steep descent on final approach with the airplane stabilized at the desired approach speed, in the proper flap configuration and with the expected power setting. All instrumentation, including the phototheodolite system, must be operating prior to reaching the starting altitude of 50 feet. (Final correlation of time-of-day and aircraft location on the runway will eventually be calculated backwards from the stopping point of the aircraft.) The pilot will fly the approach and flare segment according to the optimized technique. The landing itself is not smooth and gentle, but is usually relatively firm to minimize any "float" time over the runway. Immediately after touchdown the pilot will initiate the aerodynamic braking phase of the landing by extending speed brakes, thrust reversers, etc. When the airspeed has slowed to a value consistent with the known braking energy (slower speeds for higher weights), the pilot begins a transition to use the wheel brakes to the maximum extent. Flaps may be retracted to increase the weight on the wheels and improve braking capability. The airplane is brought to a complete stop so that the final location on the runway can be established and correlated for all data sources. If the test was expected to use maximum braking energy, a fire truck and emergency equipment will be brought into position in the event of a brake fire or blown tire.

6. Measures of Success

A successful maximum performance landing test will meet the following test criteria:

1. All instrumented parameters recorded properly.
2. The weight at landing was accurately known.
3. The final approach was at the proper speed, configuration, and power setting.
4. The landing was firm but controlled.
5. The aerodynamic and wheel braking techniques were as planned.
6. Good time correlation was obtained between the on-board and external measurements.

A sample maximum performance landing is shown.



Maximum Performance Landing Time History

Table 1-1

Table Maximum Performance Landing

Parameter	Used For
Airspeed	Compute Mach and dyn. pres
Pressure Altitude	
Outside Air Temperature	
Engine RPM	Thrust corrections to standard-day conditions
Engine tailpipe pres. & temp	
Engine inlet pres. & temp	
Fuel Flow	Compute fuel used
Radiosonde (weather balloon)	Wind and temp. corrections to standard day
Main, nose wheel shock strut position	Main and nose wheel standard day
Inertial or Phototheodolite Measurements of distance along the runway	
Radar altimeter or Phototheodolite measurements of altitude above the runway	